

# X-Ray Ring Report

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The trim magnets continue to run near maximum as a result of the upgrade to 2.8GeV low emittance operations. The situation has not affected users significantly but requires constant monitoring by the machine operators. If a trim magnet is used in a feedback system and that trim saturates, the feedback system will likely oscillate. This may affect the orbit all around the ring. Operators must be careful during the initial orbit correction process not to drive the trims too hard. Once beam is turned over to the users the operator must periodically check the trim drive levels.

The process of upgrading the trims is now under way. Operating at 2.8GeV and low emittance requires many of the trim magnets to operate near maximum current. This limits our ability to provide orbit corrections for users. Monitoring has shown that some trims near saturation now were not near saturation four months ago. This indicates that any of the X-ray trims could be a problem. We anticipate upgrading all 69 horizontal trim magnets and/or their power supplies. The task is complicated by the fact that there are six different types of trim magnets in the X-ray ring. The various upgrade options include, adding windings, lengthening the magnet, increasing the current and adding cooling to the magnet or increasing the current and using a higher temperature epoxy to pot the windings. In many cases other components will need to be moved to make room for the upgrade. The mechanical group has completed a comprehensive survey of the trim magnets and made upgrade recommendations on a magnet-by-magnet basis. Two upgraded trim magnets will be installed during each maintenance period.

The power supply group has received the first shipment of new trim power supplies. Two of the supplies have been installed at the most critical locations. The trim magnets have been assigned a priority according to the impact they will have on users. Trims used in both local and global feedback systems have top priority, followed by trims used only in local feedback systems. Trims not involved in feedback have a low priority unless they directly affect beamline operations.

The RF group modified the output transmitters that drive the RF cavities. The tuning plate assembly, designed by the vendor, provided poor RF contact, causing arcing and subsequent transmitter failure. The RF group increased the tuning plate thickness to  $\frac{1}{4}$ ", improved the sliding contacts, and added cooling channels. These upgrades allow the transmitters to operate at higher power with less heating, increasing the out-

put power from 125kW to 150kW. One of the difficulties associated with these transmitters is that the tuning of the output stage is temperature dependant and can induce beam instabilities if the heating is excessive. Reducing the operating temperature simplifies maintenance and improves reliability. These modifications have been adopted by the vendor and will be incorporated into future commercial products.

The RF group also installed a circulator in RF system 2. This device isolates the output power amplifier from the RF cavity, allowing the amplifier to drive a constant 50 ohm load regardless of beam current. Without isolation the amplifier can become unstable with small changes in tuning or small changes in the length of the transmission line. The circulator greatly simplifies tuning and maintenance of the RF system, increases efficiency, and improves reliability.

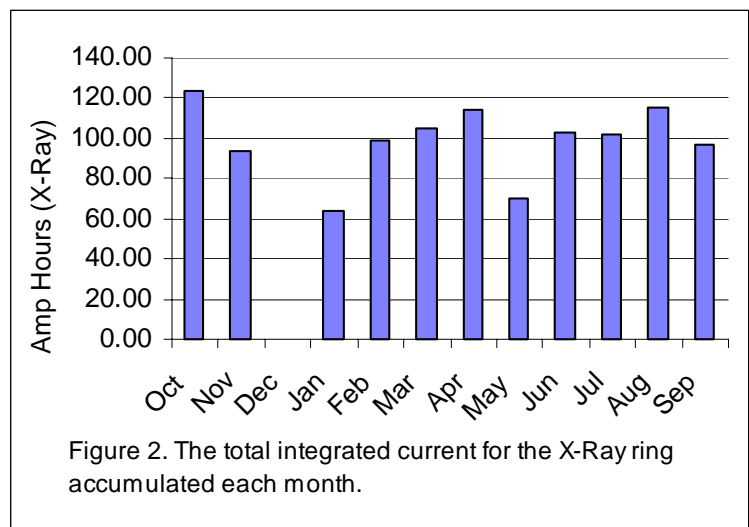
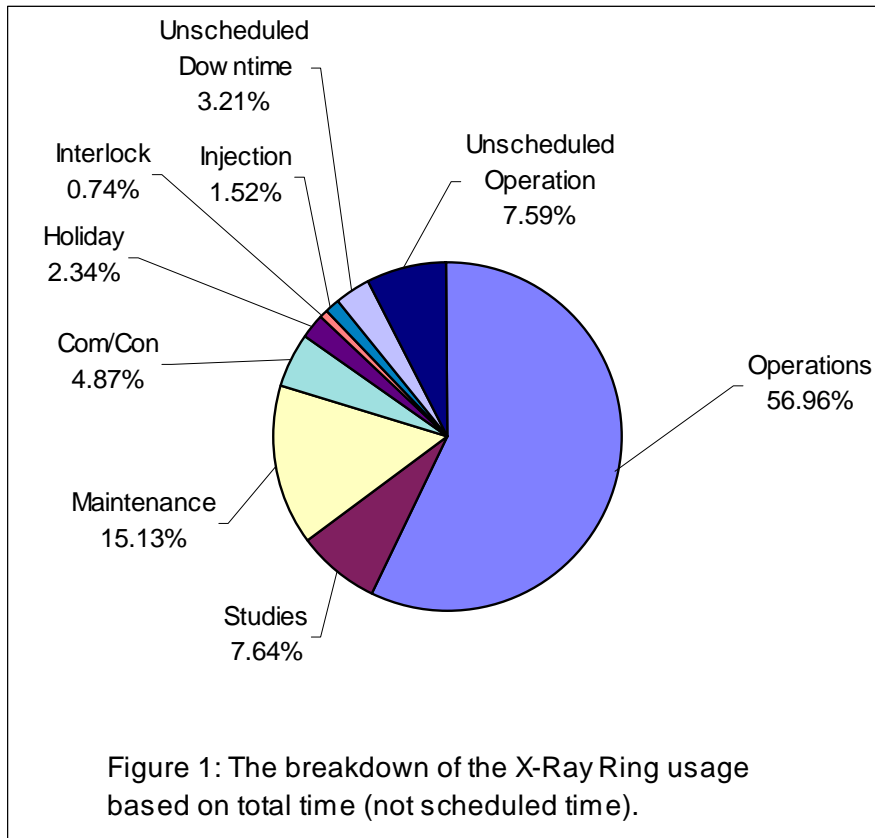
Work on the digital feedback system continues. The new system does correct the orbit better than analog global feedback. However, at this time it does not work as well as the analog local feedback systems in the insertion device straight sections. The digital system is also less tolerant of trim saturation than the analog system. Further work is required before digital feedback can be used during operations.

Problems with the Linac resulted in significant downtime for the X-ray ring in March and April. The output power from Klystron #1 began to deteriorate during March. Every effort was made to compensate for the problem in an attempt to delay repair work until the May shutdown. On March 28<sup>th</sup> the output power dropped so low that operators could no longer inject into the booster ring. Emergency repairs began immediately to replace the failed 1-year-old tube with a spare. The Power supply group and Vacuum group worked in shifts to complete the repairs as quickly as possible. The bake-out required after klystron replacement occupied much of the downtime. Once operations resumed the spare tube functioned well, until April 5<sup>th</sup> when a water leak in the high voltage tank caused it to fail. The spare was removed, dried out, and re-installed with the water disconnected. Due to the low duty cycle of the Linac the klystrons can operate without cooling water. As of this writing we have not had any more problems with the Linac. The failed tube is being rebuilt and an investigation is underway to locate a more reliable klystron supplier.

A series of active interlock beam dumps occurred in July. This was due to the orbit in the X1 area being

too close to the active interlock trip points. Moving the orbit 500mM further from the trip point solved the problem. The orbit in the X13 straight section is also near an active interlock trip point. Operators have periodically corrected the values in the ramp file to prevent the beam from dumping in this area during the ramp process.

The problems with the Linac and beam dumps are reflected in figures 1 and 2. Unscheduled downtime constituted 3.03% of the total time. This was a 1.11% increase over last year. Some studies time was turned over to the users to compensate for downtime. This resulted in an increase in unscheduled operations and a decrease in studies time as compared to last year.



# X-Ray Storage Ring Parameters

## as of December 1, 2001

Normal Operating Energies	2.800 GeV
Maximum Operating Current	280
Lifetime	~20 hours
Circumference	170.1 meters
Number of Beam Ports on Dipoles	30
Number of Insertion Devices	6
Maximum Length of Insertion Devices	< 4.50 meters
$\lambda_c(E_c)$ at 1.36 T	1.75 Å (7.1 keV)
$\lambda_c(E_c)$ at 5.0 T (W)	0.48 Å (26.1 keV)
B( $\rho$ )	1.36 Tesla (6.875 meters)
Electron Orbital Period	567.2 nanoseconds
Damping Times	$\tau_x = \tau_y = 4$ msec; $\tau_z = 2$ msec
Lattice Structure (Chasman-Green)	Separated Function, Quad Triplets
Number of Superperiods	8
Magnet Complement	<div style="display: flex; align-items: center;"> <div style="font-size: 3em; margin-right: 10px;">{</div> <div> 16 Bending (2.7 meters each)  40 Quadrupole (0.45 meters each)  16 Quadrupole (0.80 meters each) </div> </div>
32 Sextupole	(0.20 meters each)
Nominal Tunes ( $\nu_x, \nu_y$ )	9.8, 5.7
Momentum Compaction	$4 \cdot 10^{-3}$
RF Frequency	52.88 MHz
Radiated Power for Bending Magnets	198 kW (0.25A)
RF Peak Voltage	1120 kV
Design RF Power	450 kW
(Synchrotron Tune) $\nu_s$	0.0023
Natural Energy Spread ( $\sigma_e/E$ )	$9.2 \times 10^{-4}$
Natural Bunch Length ( $2\sigma$ )	8.7 cm
Number of RF Buckets	30
Typical Bunch Mode	25
Horizontal Damped Emittance ( $\epsilon_x$ )	$5.4 \times 10^{-8}$ meter-radian $0.002 \times \epsilon_x = \epsilon_y$
Vertical Damped Emittance ( $\epsilon_y$ )	$7.8 \times 10^{-11}$ meter-radian $1.1 \cdot 10^{10}$
Power per Horizontal Milliradian (0.25A)	32W

### Arc Source Parameters

Betatron Function ( $\beta_x, \beta_y$ )	1.0 to 3.8 m, 7.9 to 26.5 m
Dispersion Function ( $\eta_x, \eta_y$ )	0.47 to -0.11, -0.39 to 0.22
$\alpha_{x,y} = -\beta'_{x,y}/2$	-0.49 to 1.62, -3.4 to 4.5
$\gamma_{x,y} = (1 + \alpha_{x,y}^2)/\beta_{x,y}$	0.952 to 0.962 m <sup>-1</sup> , 0.81 to 0.52 m <sup>-1</sup>
Source Size ( $\sigma_x, \sigma_y$ )	371 to 612 μm, 27 to 53 μm
Source Divergence ( $\sigma'_x, \sigma'_y$ )	476 to 324 μrad, 9 to 7 μrad

### Insertion Device Parameters

Betatron Function ( $\beta_x, \beta_y$ )	1.60 m, 0.35 m
Source Size ( $\sigma_x, \sigma_y$ )	300 μm, 6 μm
Source Divergence ( $\sigma'_x, \sigma'_y$ )	260 μrad, 35 μrad